Amendments to the Specification:

Paragraph beginning on page 1, line 7

This application is a Continuation-In-Part of U.S. Application Serial No. 09/419,824, filed October 15, 1999, entitled "RF Modem Utilizing Saw Resonator and Correlator and Communications Transceiver Constructed Therefrom," ~~similarly assigned and~~ now U.S. Patent No. 6,535,545, incorporated herein by reference in its entirety.

Paragraph beginning on page 1, line 12

The present invention relates generally to a Radio Frequency (RF) modem and more particularly to a Surface Acoustic Wave (SAW) based spread spectrum RF modem incorporating an upconversion circuit and pulse shaping circuits for limiting the frequency output of the transmitted signal.

Paragraph beginning on page 1, line 20

Wireless communications currently may take many forms such as ultrasonic, IR and RF. A commonly used communication technique in RF wireless communications is spread spectrum. Spread spectrum communication is a communication technique whereby the transmitted signal is spread over a frequency band that is significantly wider than the minimum bandwidth required to transmit the information being sent. As a result of the signal spreading, spread spectrum systems have reduced susceptibility to interference and jamming thus ~~enable~~ enabling high levels of data integrity and security. Further, since the signal spreading process spreads the transmission power over a wide bandwidth, the power levels at any given frequency within the bandwidth are reduced significantly thereby reducing interference to other radio devices.

Paragraph beginning on page 1, line 30

Spread spectrum communication systems are generally of the direct sequence (DS) type, the frequency hopping (FH) type or are a hybrid of the two that ~~combine~~ combines DS and FH. In direct sequence spread spectrum communications, a data signal is modulated with a pseudo random chip code so as to generate a transmitted signal whose frequency spectrum is spread over a wide bandwidth. The transmitted signal has a low spectral density and appears as noise to receivers lacking the code sequence. Thus, spread spectrum communications provides increased

security for the data transmitted and reduced interference with other transmitters and receivers operating in the same environment.

Paragraph beginning on page 2, line 18

One technique for spread spectrum correlation is to convert the received signal into digital form before inputting it to a digital matched filter. Other spread spectrum correlation techniques utilize surface acoustic wave (SAW) devices to perform correlation on a received spread spectrum signal. SAW devices, constructed on quartz wafers having ~~thickness~~ a thickness of 0.5mm, permit propagation of acoustical waves on the free surface. The SAW device functions to convert electrical signals into acoustical signals and back again via piezo electric transducers.

Paragraph beginning on page 2, line 33

As the received signal propagates ~~down~~ through the SAW device, the phase structure of each element is added in or out of phase with the propagated wave. The outputs of all the elements may be summed to reach a maximum at a total correlation value. When the phase shift structure of all the elements matches the phase shifts of the propagated wave, a maximum sum, i.e., correlation, is achieved.

Paragraph beginning on page 3, line 4

Since SAW devices are by nature fixed devices, a SAW correlator is usually programmed at the time of manufacture to match a single predetermined chip code sequence. The phase shift structure of the SAW device is programmed at the time of construction through transducers placed in each element to produce an elemental phase match and cannot be changed once manufactured ~~thereby permitting~~ . Thus SAW devices generally permit correlation with a single code sequence.

Paragraph beginning on page 3, line 9

It would therefore be desirable to have [[a]] an RF modem that utilizes direct sequence spread spectrum techniques that can be constructed at low cost and small size. It is also desirable that such [[a]] an RF modem ~~utilizes~~ utilizes SAW devices for both the transmitter resonator, transmitter correlator and receiver correlator thereby reducing the size and cost of the modem.

Paragraph beginning on page 4, line 2

The present invention is a bidirectional direct sequence spread spectrum half-duplex RF modem. The RF modem can be ~~applied~~ utilized to transmit and receive numerous types of analog and digital pulse modulation. While the RF modem can be adapted to operate in numerous frequency ranges, a first example is presented herein that is constructed to operate in the 902 to 928 ~~and the~~ Industrial, Scientific and Medical (ISM) band of frequencies and a second example constructed to operate in the 2400 to 2483.5 MHz ISM band. In addition, examples are provided that utilize the RF modem of the present invention to construct various ~~type~~ types of data communications systems.

Paragraph beginning on page 4, line 16

The RF modem is constructed to operate as a pulse transmitter and receiver. It is adapted to be generic in the sense that it is versatile enough to be used in many different types of data communication systems, several examples of which are presented below. The RF modem can be used as the physical (PHY) layer in a layered communication system such as the ISO OSI communication stack. As an example, the pulse transmitter RF modem, can be used to ~~provide~~ implement various modulation schemes including, but not limited [[to]] to, On/Off Keying (OOK), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM) or any other type of analog or digital pulse modulation.

Paragraph beginning on page 11, line 7

The present invention is a bidirectional direct sequence spread spectrum half-duplex RF modem. The RF modem can be applied to transmit and receive numerous types of analog and digital pulse modulation. A first embodiment is presented comprising the core RF modem circuitry intended to operate at an RF frequency in the 902 to 928 MHz Industrial, Scientific and Medical (ISM) band of frequencies. A second embodiment is presented that comprises an upconverter/downconverter for translating the ~~resulted~~ resultant spread pulse to a desired frequency band. While the RF modem can be adapted to operate in numerous frequency ranges, an example of the second embodiment is presented herein that is constructed to operate in the 2.4 GHz ISM band of frequencies. It is not intended, however, that the present invention be limited to such example implementations shown herein, as one skilled in the art can apply the principles of the present invention to construct [[an]] RF ~~modem~~ modems having other frequencies of operation as well.

Paragraph beginning on page 12, line 13

Several key features of the RF modem of the present invention include: (1) the incorporation in the RF modem of two different Surface Acoustic Wave (SAW) devices fabricated on a single monolithic substrate whereby a first SAW device is used to form the resonator in the transmitter portion of the modem while a second SAW device is used to form the correlator in the transmitter and receiver ~~portion~~ portions of the modem; (2) the very low amount of power consumed by the modem; (3) the very narrow pulse that is received during operation which results in improved SNR; and (4) the effective energy per bit transmitted is 10 dB above the transmitter energy, due to the processing gain of the modem.

Paragraph beginning on page 13, line 23

A signal generator 14 functions to generate the oscillator and clock signals used by the modem, including the Radio Frequency (RF) signal. In the example RF modem shown herein, the RF signal is chosen to generate a transmit pulse in the 900 MHz ISM band, with ~~an RF~~ a frequency equal to 915 MHz.

Paragraph beginning on page 16, line 8

Alternatively, the interrogating pulse ~~can be~~ is generated using an RF switch adapted to create short pulses of the RF signal. The pulse durations are approximately within a range of 0.5 to 2 chips (i.e., 25 to 100 ns). The RF switch preferably is adapted to provide high isolation of at least 50 dB from input to output when not in an 'on' state. The input impedance of the switch is preferably no lower than [[10K]] 10k Ohm and no higher than 5 pF. The output impedance is preferably 50 Ohm. A positive input on the control input on the Data In signal ~~puts~~ places the switch in the on or conducting state. Alternatively, the switch can be adapted to turn on when a negative or zero signal is input to the control input.

Paragraph beginning on page 17, line 3

The resonator 56 may comprise any suitable resonator but is preferably a SAW resonator device whose center frequency determines the frequency of oscillation of the oscillator. The construction of the SAW resonator is described in more detail hereinbelow. The output of the oscillator is coupled via capacitor 72 to a first switch comprising FET transistor 78 whose gate is connected to ground via resister 76 and to the Data In signal via resistor 74. The source terminal

is connected to V_{CC} via a voltage divider comprising resisters 80, 82 coupled to RC comprising resister 84 and capacitor 86.

Paragraph beginning on page 17, line 10

The output of FET 78 is coupled via coupling capacitor 92 to a second switch comprising FET transistor 98 whose gate is connected to ground via resister 94 and to the Data In signal via resistor 94. The source terminal is connected to V_{CC} via a voltage divider comprising resisters 88, 82 coupled to RC comprising resister 110 and capacitor 114. Two cascaded switches are used in series to provide a high level of backward isolation when the switch is off. In the case when a single switch does not provide sufficient isolation, two switches effectively double the isolation. Such a series combination can provide on the order of 50 dB of isolation between input and output. In addition, the switch is adapted to open relatively quickly, i.e., on the order of 2 ns.

Paragraph beginning on page 18, line 17

The SAW resonator and correlator devices of the present invention will now be described in more detail. A pattern diagram illustrating the surface acoustic wave device including a SAW resonator and SAW correlator is shown in Figure 6. The SAW device 20 is constructed on a single piezoelectric substrate preferably made of quartz crystal, ST cut. The substrate may be constructed of materials other than quartz so long as the material used has acceptable temperature-stable properties. The SAW device 20 comprises two SAW components: a resonator 190 and a correlator 160. The correlator is a passive element which functions as a direct sequence spread spectrum spreading and de-spreading element. Both are described below in more detail beginning with the resonator. Note that the SAW resonator and correlator are adapted to fit onto a die size of approximately 1.5 mm^2.

Paragraph beginning on page 18, line 27

The resonator 190, a two terminal device, is coupled to the oscillator circuit 42 (Figure 2), and in more detail is shown coupled to the base of transistor 64 (Figure 5). The resonator device 190 comprises input terminals 192 connected to signal electrodes 194, 198, 202. The signal electrodes 194, 198, 202 have comb shapes 196, 200, 204, respectively, for converting an electrical signal into surface acoustic waves. Note that the side electrodes 196, 204 span the entire distance unlike electrode 200. The two sets of signal electrodes, separated from each other

by a predetermined distance, are operative to convert the surface acoustic waves into an electrical signal. Both signal electrodes are formed on the quartz crystal substrate using well known lithography techniques and are constructed of any suitable conductive material such as aluminum (Al), ~~Silver (Au), Ag~~ Gold (Au), Silver (Ag), copper (Cu) or the like having low electrical resistivity. Aluminum (Al) is preferable as it has the advantages of being low cost and etches easily.

Paragraph beginning on page 20, line 1

The signal electrodes and absorbing surfaces are formed on the quartz crystal substrate using well known lithography techniques and are constructed of any suitable conductive material such as aluminum (Al), ~~Silver (Au), Ag~~ Gold (Au), Silver (Ag), copper (Cu) or the like having low electrical resistivity. Aluminum (Al) is preferable as it has the advantages of being low cost and etches easily.

Paragraph beginning on page 21, line 11

The actual code used to configure the SAW correlator device 20 is important to the operation of the system. The spreading code sequence is preferably chosen, however, so as to maximize one or more desirable characteristics including, but not limited to, autocorrelation, noise immunity, transmit spectrum and low intersymbol interference (ISI). In the United States, for transmission in the ISM band, the FCC requires that the code sequence comprise 10 or more chips and that the system exhibit ~~processing~~ a processing gain of greater than or equal to 10 dB. Therefore, the present invention utilizes a short code sequence that is close to the FCC minimum.

Paragraph beginning on page 21, line 27

The correlator coefficients are +1 for 1's and −1 for 0's whereby a 13 chip spreading code results in the following coefficients used in the construction of the SAW correlator: +1, +1, +1, +1, +1, -1, -1, +1, +1, -1, +1, -1, +1. A plot illustrating the frequency response of the SAW device of the RF modem is shown in Figure 8. The power in dB is plotted versus frequency. The frequency response is adapted to cover the ISM band (i.e., 902 to 928 MHz). The time representation of the frequency response, represented by $h(t)$, is used to calculate the autocorrelation function $a(t)$ whereby $a(t) = h(t) * h(-t)$, a convolution of $h(t)$ [[and]] with $h(-t)$. A plot illustrating the autocorrelation of the SAW correlator device is shown in Figure 9. Each lobe of the autocorrelation is approximately 50 ns wide. The processing gain ratio is at least 11

dB = 10*log10(13). Note that the 13 peaks or lobes (12 small peaks with one large peak in the center) correspond to the 13-bit Barker code configured in the correlator.

Paragraph beginning on page 22, line 18

In the case where the pulse compression used is linear FM, the signal can be expressed as in Equation 1 above ~~but wherein~~ where the frequency function $f(t) = a \cdot t^2$ is a non-linear rising function with time. Note that other functions of frequency are also suitable as well.

Paragraph beginning on page 24, line 5

In the low speed mode of operation, the correlator is interrogated with pulses that are spaced far enough apart such the pulses output from the correlator do not overlap each other. In other words, no Intersymbol Interference (ISI) is generated. As the interrogating pulses are spaced closer and closer together, the pulses output from the correlator begin to overlap each other thus creating ISI. Spacing the interrogating pulses closer together ~~permit~~ permits higher data rates to be achieved.

Paragraph beginning on page 24, line 27

A diagram illustrating waveform traces of signals of the transmit RF front end circuit is shown in Figure 13. The controller is operative to generate the timing and control signal required by the transmit circuit. The transmit control portion of the controller may be implemented as a state machine. In this case, the state machine is positive edge triggered thus starting a sequence of activating the amplifiers each time the data in signal line transitions from low to high.

Paragraph beginning on page 25, line 28

The signal output of the receive RF front end circuit is input to the SAW correlator via matching network 22. The correlator functions to de-spread the received signal from the original code sequence to a relatively narrow pulse, e.g., from a wide pulse of 650 ns to a pulse [[a]] width of approximately 50 ns.

Paragraph beginning on page 26, line 24

The decision stage is the final stage in the receive path. The output of this stage is a digital pulse that indicates whether a valid signal has been detected or not. It comprises a comparator [[486]] 254 (e.g., Schmitt trigger comparator) whose output RX_OUT is input to the

controller. The controller implements a state machine that functions to generate the data out line to the host.

Paragraph beginning on page 27, line 14

To provide two modes of operation, an offset voltage V_{OFF} is subtracted from the output of the slow peak detector V_{SPK}. The signal V_{SPK} is input to a summer 252 before being input to the inverting input of the comparator 254. The output of the fast peak detector V_{FPK} is input to the non-inverting input of the comparator. An analog mux 250 selects ~~with~~ which offset voltage to subtract from the slow peak detector voltage. For the high data rate mode, a threshold 3 dB below peak detection is used (i.e. 3α offset) and for the low data rate mode, a threshold 6 dB below peak detection is used (i.e. 6α offset), as expressed below in Equation 2.

$$\begin{aligned} \{Mode\,1\} &: V_{REF} = V_{SPK} - 3\alpha \\ \{Mode\,2\} &: V_{REF} = V_{SPK} - 6\alpha \end{aligned} \qquad (2)$$

The OFF_SEL signal from the controller determines ~~with~~ which of the two modes the receiver operates in. In addition, the Rx_PWR signal from the controller controls the supply V_{CC} to the LNA3, fast and slow peak detectors and to the comparator via switches 256, 244, 242.

Paragraph beginning on page 29, line 19

In the second embodiment of the RF modem, an upconverter/downconverter functions to translate the spread pulse to/from a higher frequency. The majority of the circuitry of the modem does not change except for the signal generator 14, transmit RF front end 26 and receive RF front end circuits 32. The ~~modification~~ modifications necessary include the oscillator signal generation and mixer circuitry required to perform the up/down conversion.

Paragraph beginning on page 30, line 12

The output of the oscillator comprises the IF oscillator signal which is multiplied by four to generate the desired up conversion LO frequency (e.g., 1952 MHz). Note that the use of PLL circuits to perform the frequency multiplication may not be sufficient if fast wake up times are desired. In this case, it is preferable to utilize a quad self-mixing based components 314, 316. In addition, the circuit ~~preferable sufficiently~~ preferably suppresses sufficiently harmonics other then the LO frequency (e.g., 1952 MHz).